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Tetralopha robustella ZELLER[1/], IN NORTHEAST FLORIDA[2/]

SLASH PINE PLANTATIONS

U. S. FOREST SERVICE
PINEVILLE, LOUISIANA

U. S. DEPARTMENT OF AGRICULTURE -- FOREST SERVICE
SOUTHEASTERN AREA, STATE AND PRIVATE FORESTRY
RESOURCE PROTECTION UNIT, FOREST INSECT AND DISEASE MANAGEMENT GROUP

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BIOLOGY OF THE PINE WEBWORM, *Tetralopha robustella* ZELLER[1/], IN NORTHEAST FLORIDA[2/] SLASH PINE PLANTATIONS

by

G. D. HERTEL[3/], and D. M. Benjamin[4/]

ABSTRACT

The pine webworm has six larval instars and at least three generations per year in young slash pine plantations in northeast Florida. First, second, and third instar larvae mine needles. Fourth, fifth, and sixth instar larvae share a common frass nest on a branch or the main bole and move out to collect needles to take back to a frass nest where they feed. Sixth instar larvae construct cocoons and pupate in the soil. Adult moths emerged between April and October, according to light trap collections, and laid eggs on the flat surface of the needles. Only three male moths were attracted to female (5 to 6) baited sticky board traps during two field seasons. Eleven species of parasites were reared from field-collected colonies of the pine webworm during a 2-year period. Syzeuctus elegans *(Cresson) was the most common hymenopteran and* Eufrontina *n. sp. the most common dipteran parasites found. Of all the pine webworm colonies collected in 1972 and 1973, one or more parasites were found in 9%, 17%, 50%, and 47% of the field colonies on 1-, 2-. 3-, and 4-year old pines respectively. The pathogen,* Beauveria bassiana *(Bals.) Vuill, was isolated from a dead larva.*

The unsightly frass nests (Fig. 1) of the pine webworm, *Tetralopha robustella* Zeller, observed on hard and soft pines in eastern North America may elicit concern of forest managers and Christmas tree producers.

Literature concerning the pine webworm is not voluminous; Wallesz and Benjamin (1960) report biological studies and associated natural control factors in Wisconsin. Recent papers describe the influence of site preparation on pine webworm establishment on southern pines (Hertel and Benjamin 1977), the influence of the pines' geographical seed source on infestations (Hertel and Benjamin 1975) and chemical control (Merkel and Hertel 1976).

In the Lake States, nests on Christmas trees may render trees unfit for market (Wallesz and Benjamin 1960). Feeding on young southern pines has been reported causing tree mortality (Beal 1952; Huckenpahler 1953). Pine webworms may be a problem in newly established seed orchards and in progeny tests where growth and tree form are evaluated. We present here a detailed description of the biology of the pine webworm on planted slash pines, *Pinus elliottii* Engelm. var. *elliottii*, in northeast Florida.

LIFE CYCLE AND SEASONAL HISTORY

Methods

The life cycle and seasonal life history of the pine webworm was determined on slash pine in northern Florida in 1972, 1973, and January 1974. In 1972, colonies were collected from 1- to 4-yr-old slash pine plantations located in the Owens-Illinois, Inc., Lake Butler Management

Fig. 1. Pine webworm frass nest. Old mined needles located to the right and above the frass nest.

Area in Union and Columbia Counties, Florida. Site preparation practices, after removal of the original pine forest and prior to planting, included a burn, K-G-blade (D-8 tractor with V-shaped blade), windrowing the debris, and bedding of the soil. The seedlings were planted by machine at a 1.8 x 3.0 m spacing.

Some of the pine webworm frass nests were collected and adults reared in plastic boxes (30 x 15 x 12 cm). Larvae were removed from other frass nests, preserved, and their length and head capsule widths measured. Preserved larvae were put successively in boiling water, KAAD solution, and 70% ethanol: larval head capsule widths were measured later.

In 1973, colonies were collected from a 2-yr-old slash pine plantation in the Lake Butler Management Area, Union County, Florida. Each colony was dissected and the larvae were measured and individuals or groups were placed in a small plastic cup (3 cm across at bottom, 4 cm at top, 5 cm high) for rearing at room temperature. Those reared as individuals were measured daily. Fresh pine needles were placed in the cup each day.

During the winter, soil samples (15.2 cm deep, drip line to stem) were taken from beneath infested trees and sifted for cocoons; those containing last instar larvae or pupae were placed in plastic cups for rearing to adults. The sex ratio of pupae was determined by using the genetal apertures located on the ventral surface of the ninth abdominal segment and the sex ratio was then calculated.

Seasonal occurrance and relative abundance of the adult moth was determined by use of light traps. Specific methods for many of the individual studies will be presented in the next section.

Results

The pine webworm laid overlapping eggs (1 to 10) on the flat surface of pine needles. Upon eclosion, larvae mined into individual pine needles. First, II, and III instar larvae mined needles; also, II and III instar larvae abandoned mining of the needles and fed among the mined needles. All larvae had abandoned the mined needles or the area adjacent to the mined needles by the IV instar in 1973. Instars II through VI left the area of needle mining and moved to the branch stem or main stem. Fourth, V and VI instar larvae were found in the common frass nest on branch stems or main stems. Larvae left the nest and brought pieces of needles on which they feed back into the nest. The sixth instar larvae moved from the frass nest to the ground where they spun cocoons and pupated.

The mean number of eggs per mass collected from slash pine seedlings in the laboratory was 3.7 $\pm$ 1.2 (range 1 to 10, n = 57). Three egg masses collected in the field had a mean of 7.7 eggs per mass and a range of 6 to 10. Single eggs were 1 mm in length.

The laboratory-reared pine webworm had six larval instars as indicated by the frequency distribution for head capsule widths of field-collected larvae (Table 1). There was some variation in the head capsule ratio

TABLE 1. Mean head capsule widths for pine webworm larvae collected on slash pines - from May-October 1973, Union Co., FL

Instar	Mean head capsule width and standard deviation (mn)	Range (mm)	Number of larvae	Dyar ratio
I	0.32 ± .03 (0.37)[1]	0.28 - 0.36	71	
II	0.43 ± .03 (0.53)	0.40 - 0.48	91	0.74
III	0.68 ± .09 (0.73)	0.52 - 0.80	250	0.63
IV	0.97 ± .09 (0.97)	0.84 - 1.12	187	0.70
V	1.40 ± .15 (1.33)	1.20 - 1.68	228	0.69
VI	2.05 ± .16 (1.83)	1.76 - 2.40	316	0.68

[1] In parentheses are mean webworm head capsule widths reported in Wisconsin by Wallesz and Benjamin (1960).

when Dyar's Rule was applied; also, these ratios differ slightly from those reported for Wisconsin by Wallesz and Benjamin (1960).

Number of Generations per Season

Pine webworm larvae were not observed in newly planted plots on 8 March, 19 April, or 23 May 1973 during the first growing season. On 19 June, pine webworm needle mining was observed on two trees and two trees had colonies containing V or VI instar larvae. The numbers of infested trees increased in September (Table 2); and by 13 December all larvae, except those on five trees, had moved to the ground. On 3 January 1974, no active colonies were observed.

During the same period (March to January) webworm larvae were collected on slash pines outside the immediate study area. We established that three webworm generations per year occurred; the first two generations contained relatively few individuals and while the fall generation contained many individuals (Table 3), this contrasts with the one generation reported to occur in Wisconsin (Walleze and Benjamin 1960). The only instar collected every month between June and January was the VI instar.

In the second growing season of the slash pine plantation, the first needle mining was observed on 23 April 1973. Other needle mining was observed in late May and the first two weeks of June. The needle mining was observed again in September. In the warm winter of 1974, needle mining was seen in January (Table 3).

Table 2. Chronological infestation of slash pine by pine webworm during the pine's first growing season in Union County, FL 1973.

Date	Webworm life stages				
	Larval instar				
	I, II	III	IV, V	VI	Pupa[1/]
	Numbers of trees[2/] infested				
8 Mar. 73	0	0	0	0	0
18 Apr.	0	0	0	0	0
23 May	0	0	0	0	0
19 June	2	0	0	2	0
24 July	1	0	1	0	0
20 Aug.	0	2	0	5	1
14 Sept.	55	7	1	0	2
10 Oct.	16	57	22	4	0
9 Nov.	0	76	14	47	0
13 Dec.	0	0	1	4	0
28 Dec.	0	0	0	1	0
3 Jan. 74	0	0	0	0	0

1/ Pupa in frass nest.

2/ Total numbers of trees in plots = 400.

TABLE 3. Percentage of pine webworm larvae, by instar, collected from slash pines outside study plots in the first and second growing season in Union County, FL - 1973.

Month	Plantation Age	I	II	III	IV	V	VI	Numbers of larvae head capsules measured
May	1	-	-	-	-	-	-	0
	2	16.7	10.6	36.4	18.2	10.6	7.5	66
June	1	0.0	0.0	50.0	15.4	7.7	26.9	26
	2	0.0	14.3	35.7	3.6	21.4	25.0	28
July	1	29.4	0.0	23.5	11.8	5.9	29.4	17
	2	0.0	0.0	19.2	23.0	28.9	28.9	52
Aug.	1	0.0	22.2	11.1	11.1	33.4	22.2	9
	2	17.8	6.7	20.0	8.9	13.3	33.3	45
Sept.	1	23.5	29.4	23.5	0.0	17.7	5.9	17
	2.	24.0	28.0	20.0	16.0	4.0	8.0	25
Oct.	1	7.1	10.7	28.6	25.0	10.7	17.9	28
	2	0.0	11.3	37.5	25.0	16.2	10.0	80
Nov.	1	0.0	0.0	5.9	13.7	39.2	41.2	51
	2	0.0	0.0	5.9	5.9	49.0	39.2	51
Dec.	1	0.0	0.0	0.0	0.0	0.0	100.0	18
	2	0.0	0.0	0.0	3.6	7.1	89.3	28
Jan. (1974)	1	0.0	0.0	0.0	0.0	0.0	100.0	3
	2	36.3	0.0	18.1	0.0	9.1	36.4	11

No larvae were collected from pines outside the study plots until 7 May 1973 when one each of instars II, III, and V were collected. These data substantiate the occurrence of three generations per year with the greatest numbers occurring in the fall (Table 3).

Larval counts per colony were 2.4 ± 2.0 and 2.2 ± 1.7, respectively, (= frass nest) on first and second growing season slash pines in 1973. The largest colony collected (22 June) from first growing season slash pines contained 10, II and IV instar larvae. The largest colony collected (6 September) from second growing season slash pine contained 9, II to VI instar larvae.

Forty-two male and 36 female pupae were collected. The mean weight of males collected from the soil beneath infected trees in the field was 62.2 ± 17.9 mg and were 10.6 ± 1.1 mm in length. The females weighed 69.5 ± 17.9 mg and were 10.9 ± 1.2 mm in length.

Webworm cocoons collected beneath infested trees in February and March 1973 contained a VI instar larva or pupa. Adult emergence was indicated in March and April by the collection of empty puparia. By April, no living larva or pupa were seen in cocoons.

In 1972, the first pine webworm adult emerged from field-collected soil in the insectary on 16 March and the last adult emerged on 29 April. The winter of 1973 was unusually mild and first adult emergence occurred 16 January and the last on 12 April. Of pine webworm adults reared in 1972, 175 were males and 194 females (sex factor = 0.53). In 1973, 206 were males and 186 females (sex factor = 0.47)

Pine webworm colonies infest young pines and also larger trees. During monthly observations on trees 12 to 14 m in height at the McCloskey Slash Pine Seed Orchard near Lake City, FL, 36 active webworm colonies were found between January and March. At this time, however, only three active colonies were found on 2-yr-old slash pines.

ADULT FLIGHT PERIODS

Methods

The pine webworm adult flight period was assessed with omni-directional (OD) black light-blue fluorescent light traps (Frost 1962) on the Olustee Experimental Forest, Baker County, Florida. In 1972 traps were placed in an adjacent natural stand of longleaf pine, *P. palustris* Mill, at 1.2 and 18.3 m height, and one trap was placed in a nearby cypress swamp at 18.3 m height. Traps were operational from 7:00 PM to 7:00 AM on Monday through Friday. In 1973, all light traps were at 18.3 m height and examined daily from 5 February in the pine stand and from 20 April in the swamp. Trapping ceased on 29 December.

During 1972, four to six freshly-emerged virgin adult females were placed in a 0.6 m square hardware screen trap located on a 10.3 cm square hardware cloth cage treated with Tack-Trap®. The trap was located 1.2 m above the ground east of a 2-year-old slash pine stand and was maintained daily with fresh virgin females from 12 April to 12 June and 22 June to 5 July. The sticky board traps set out periodically with four to six virgin females from 22 June to 8 October 1972.

In 1973, a 1-quart ice cream carton coated with Tack-Trap on the inside was baited with four to six females and placed adjacent to a 3-year-old slash pine stand another carton was placed under the light trap in the 80-year-old loblolly stand. The traps were maintained from 12 June to 30 November 1973.

Results

Pine webworm adults were collected in the light traps between the middle of April and the beginning of October. In Wisconsin, adults were only collected in June, July, and August (Wallesz and Benjamin 1960). The largest numbers of adults were collected during the first 2 weeks of June in Florida. Twenty-nine females and five males were collected in 1972, 24 females and 12 males in 1973, and 25 females and six males in 1974.

No males were collected on the stick-board traps in 1972. During 1973, female-baited ice-cream carton traps collected three males on 8 September.

LABORATORY REARING AND NATURAL CONTROL FACTORS

Methods

Rearing of the pine webworm through its entire life in the laboratory presented no major difficulties.

Larvae collected from the field in May to August 1973 were fed fresh needles on alternate days and were reared to adults in 12 x 16 x 6 cm plastic boxes in the laboratory at room temperature. The duration of

time from a given instar to adult eclosion decreased as larval age at collection time increased (Fig. 2). Larvae collected between September and December required about the same length of time to produce adults.

The webworm was reared from egg to adult by placing male and female moths in a 47 cm sq screen cage with a pine seedling. The adults mated and the female deposited eggs on the pine needles. The eggs were removed and larvae reared in plastic cups or the larvae were left on the seedling to complete their life cycle. Rearing was at room temperature (19° to 24°C.), and at 25°C. with a 12L:12D light cycle to compare rates of development.

The insect completed one cycle from egg hatch to adult eclosion in about 50 days at room temperature (19° to 24°C.) (Table 4). At a constant 27°C. in incubators, about 20 additional days were required to complete the cycle. The colony was maintained in the laboratory for 2 years without addition of field collections.

Natural Control Factors

The relative abundance of biotic factors, especially parasites of the pine webworm larvae and pupae, were assesssed from the rearings. All the parasite species reared were sent to the U.S. National Museum for identification.

Parasites

Parasites were reared from pine webworm colonies collected in 1-, 2-, 3-, and 4-year-old slash pines. In 1972, the first, second, and fourth growing season plantations were located within 4.8 kl

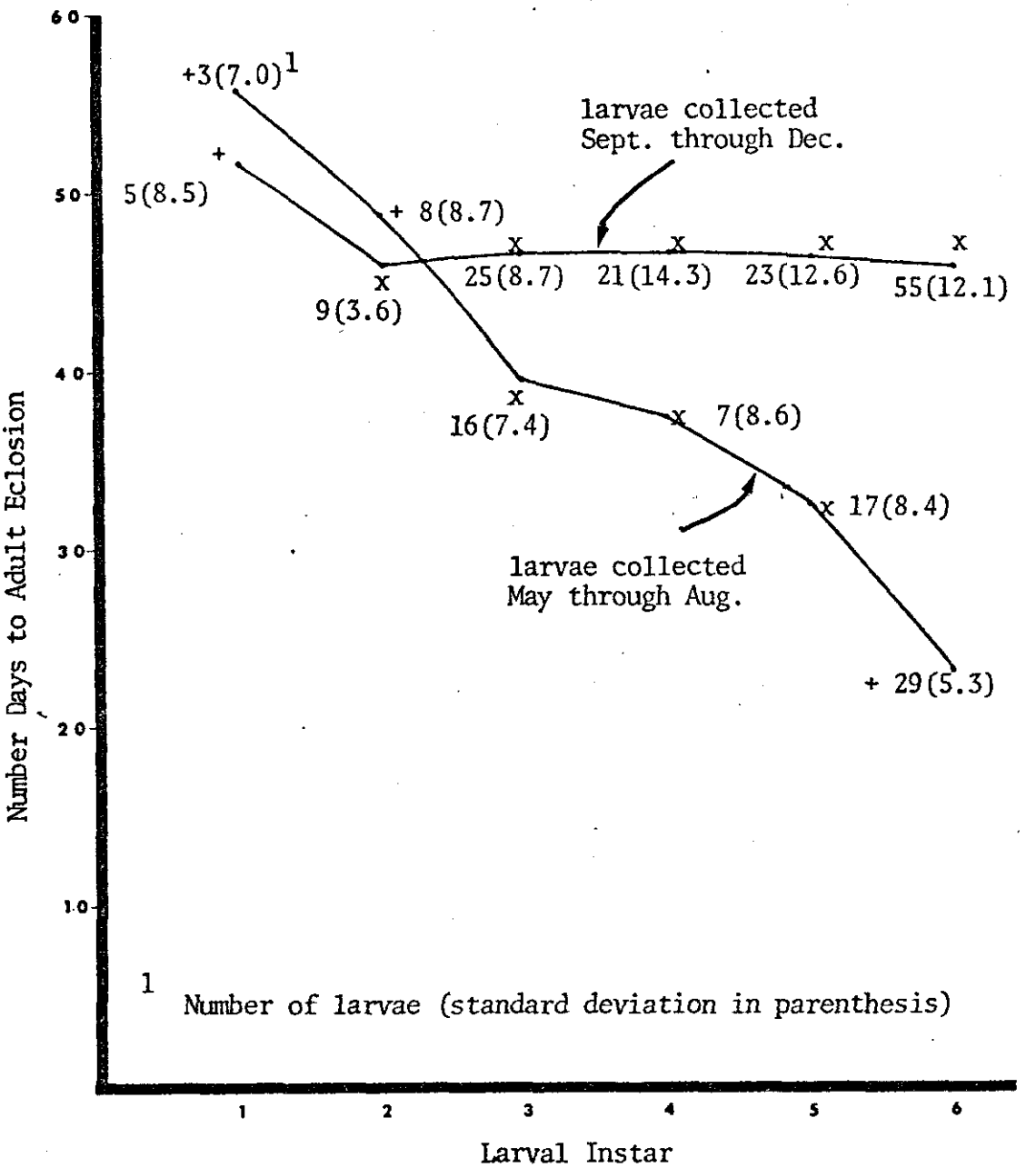

Figure 2. Number of days for pine webworm larvae collected from the field to become adults when reared at room temperature. Numbers at each point refer to number of larvae (standard deviation).

TABLE 4. Duration of larval and pupal stages reared from eggs of the pine webworm reared at constant and room temperature in the laboratory.

Rearing conditions	Duration of Life Stage			Individuals
	Larval stage	Pupal stage	to Eclosion	
	No. days ± Standard deviation			No.
Constant temperature[1]	60.2 ± 9.1	15.5 ± 1.6	75.1 ± 8.7	17
Constant temperature[2]	54.5 ± 1.0	13.7 ± 1.9	68.2 ± 1.0	4
Room temperature[3]	42.1 ± 5.3	10.3 ± 4.0	52.9 ± 6.9	50
Room temperature[4]	36.4 ± 0.9	14.0 ± 4.2	50.4 ± 5.0	5

1 4 Jan. to 1 May '74 27°C 12 light:12 dark

2 22 April to 30 June ' 74 27°C 12 light:12 dark

3 19 Aug. to 19 Nov. '73 room temperature (19-24°C) natural light

4 22 April to 30 June '74 room temperature (19-24°C) natural light

of each other. In 1973, the first, second, and third growing season plantations were within 4.8 kl of each other. The third (1972) and fourth (1973) growing season plantations were 12.8 to 16 kl from the other plantations.

Among colonies collected in May through November 1972 and 1973, one or more parasites were reared from 9.2% (11/119) of the first growing season colonies, 17.2% (53/308) second, 50.0% (22/44) third, and 47.2% (25/53) of the fourth growing season collections. None of the parasites collected in this study were collected in the Wisconsin studies (Wallesz and Benjamin 1960). Parasites involved in Florida were:

1. *Apanteles epinotiae* Viereck (Hymenoptera:Braconidae)
   (One collection; July; second growing season slash pine)
2. *Bracon* sp. (Hymenoptera:Braconidae)
   (One collection; February; fourth growing season slash pine; dead III instar larva)
3. *Eufrontina* n. sp. (Diptera:Tachinidae)
   The adult flies were reared from pine webworm pupae collected in the soil. The fly puparium was inside the pine webworm pupa and the adult fly emerged from the anterior. June collections were made from larvae that were collected in the field, pupated in the lab, and from which the flies emerged. (10 collections; (one parasite/collection); December through March, June; first through third growing season slash pine).

4. *Eusisyropa boarmiae* (Coquillett)(Diptera:Tachinidae)
   (Four collections; October, November, December; first and second growing season slash pine; dead VI instar larva and pupa)
5. *Hormius vulgaris* Ashmead (Hymenoptera:Braconidae)
   Small groups of 3 to 9 parasitoid larvae were observed feeding on dead V and VI instar pine webworm larvae in the frass nest. Probably in response to the parasite, the pine webworm larva would spin its cocoon in the frass nest. The parasitoid larvae formed white cocoons in the frass nest. (24 collections; all months except August and September; first through fourth growing season slash pine)
6. *Macrocentrus robustus* Muesebeck (Hymenoptera:Braconidae)
   (Three collections; May and July; second growing season slash pine; dead III and IV instar larva)
7. *Meteorus tetralophae* Muesebeck (Hymenoptera:Braconidae)
   (One collection; June; fifth growing season slash pine; dead VI instar larva)
8. *Nemorilla pyste* (Walker)(Diptera:Tachinidae)
   (One collection; March; third growing season slash pine; dead pupa in cocoon)
9. *Spilochalcis flavopicta* (Cresson)(Hymenoptera:Chalcididae)
   This parasite emerged from pine webworm pupae collected in the frass nest on the tree. However, 99% of the pine webworm pupae that ultimately emerge in the field as adults

pupate in the ground. The adult emerged from the anterior end of the pine webworm pupa. One collection was made where a pine webworm larva pupated and had this parasite emerge. (16 collections; June, August, and November; first through fourth growing season slash pine)

10. *Syzeuctus elegans* (Cresson) (Hymenoptera:Ichneumonidae)

The most common parasitoid reared from webworm colonies was *Syzeuctus elegans*. *S. elegans* larvae emerge from the VI instar pine webworm larva and spin cocoons next to it in the frass nest. The youngest dead pine webworm larva collected in the field was a II instar.

The percentage of pine webworm colonies harboring the parasite increased from 7.1% in growing season one to 18.2% during the second growing season and to 37.0 and 41.7%, respectively, for the third and fourth growing season (Table 5). It was seen commonly as long as the pine webworm larvae were found on its host tree.

In 1973, *Syzeuctus* was not collected from pine webworm colonies in the first growing season plantation and few (3.3%) were collected during the second growing season (Table 5). The second growing season in 1973 was the same plantation as the 1972 first growing season plantation; the third (1973) was the same as the second (1972); the fourth (1973) was the same as the third (1972).

TABLE 5. Numbers and percentage of pine webworm colonies containing *Syzeuctus elegans* collected from first, second, third, and fourth growing season slash pines in Union Co. FL (1972, 1973).

Collection period		Webworm colonies containing *Syzeuctus elegans*							
		1st growing season		2nd growing season		3rd growing season		4th growing season	
Month	Year	#	%	#	%	#	%	#	%
April	72	-	-	-	-	-	-	4/8	50.0
May		0/1	0.0	0/3	0.0	0/1	0.0	4/6	66.7
June		0/4	0.0	1/9	11.1	2/4	50.0	2/8	25.0
July		0/5	0.0	4/8	50.0	2/5	40.0	2/3	66.7
Aug.		0/4	0.0	2/8	25.0	3/3	100.0	2/4	50.0
Sept.		0/4	0.0	1/4	25.0	0/4	0.0	1/5	20.0
Oct.		0/4	0.0	2/18	11.1	2/7	28.6	1/5	20.0
Nov.		1/4	25.0	0/5	0.0	1/3	33.3	1/5	20.0
Dec.		0/1	0.0	-	-	-	-	-	-
Jan.		1/1	100.0	-	-	3/3	100.0	3/4	75.0
May	73	-	-	0/11	0.0	-	-	-	-
June		0/4	0.0	0/10	0.0	3/3	100.0	-	-
July		0/6	0.0	1/14	7.1	1/3	33.3	1/3	33.3
Aug.		0/3	0.0	0/3	0.0	1/1	100.0	1/2	50.0
Sept.		0/3	0.0	0/9	0.0	0/2	0.0	1/1	100.0
Oct.		0/6	0.0	1/8	12.5	-	-	0/1	0.0
Nov.		0/4	0.0	0/3	0.0	-	-	-	-
Dec.		-	-	0/2	0.0	-	-	-	-
TOTAL	72	2/28	7.1	10/55	18.2	10/27	37.0	20/48	41.7
TOTAL	73	0/26	0.0	2/60	3.3	5/9	55.6	3/7	42.8
		(0,3)	1.0	(4,13)	0.8	(9,19)	0.7	(17,39)	0.7

Number of webworm colonies represents only colonies collected from which webworm or parasites emerged.

The mean number of *S. elegans* adults emerging from infested colonies was 2.1 $\pm$ 1.5; the number of pine webworm adults emerging from the same colonies was 2.1 $\pm$ 1.5. This is compared with 3.1 $\pm$ 2.0 pine webworm adults emerging from colonies not infested by any parasites. These figures are from all colonies collected in 1-, 2-, 3-, and 4-yr-old slash pine plantations in Union County in 1972 and 1973.

11. *Trathala tetralophae* (Cushman)(Hymenoptera:Ichneumonidae)
This parasite was fairly common in 1972 and 1973. A greyish parasite cocoon was found near a dead IV or V instar pine webworm larva. (16 collections; May, June, July; first, second, and third growing season slash pine)

Pathogens

A dead larva covered with white mycellium, *Beauveria bassiana* (Bals.) Vuill., was found in a frass nest on a 2-year-old slash pine in Columbia County, Florida. This pathogen was isolated and identified by G. E. Allen, Department of Entomology, University of Florida.

ACKNOWLEDGEMENTS

We thank Mr. Roger Hunziker, Forester, Owens Illinois, Inc., for assistance in location of the study areas. We also thank the taxonomists at the Systematic Entomology, ARS, USDA, U.S. National Museum, Washington, D.C. and at the Division of Plant Industry Entomology Section, Gainesville, Florida for identifications of the parasites.

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Footnotes

[1] Lepidoptera:Epipaschidae

[2] Part of a thesis submitted to the Department of Entomology, University of Wisconsin, Madison. In partial fulfillment for the Doctor of Philosophy. Received for publication.

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